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U.S. Army Armor Human Research Unit
Fort Knox, Kentucky

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HUMAN RESOURCES RESEARCH OFFICE
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US Army Armor Human Research Unit
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An Investigation of Training to Discriminate Between the Tracked and Wheeled Vehicle Signals of the AN/TPS-33 Radar

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Research Memorandum
June 1962

A report of work done in connection with Subtask XIII, ARMORNITE, Task 11-27, "Human Factors in Armor Operations under Conditions of Limited Visibility"

Norman Willard, Jr.
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Director of Research

Research under the technical supervision of
HUMAN RESOURCES RESEARCH OFFICE
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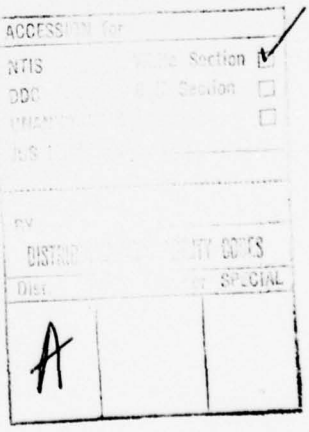

An Investigation of Training to Discriminate Between the Tracked and Wheeled Vehicle Signals of the AN/TPS-33 Radar

PROBLEM

The data obtained from a recent study did not substantiate the widely held belief that ground surveillance radar operators can readily discriminate signals produced by tracked vehicles from signals produced by wheeled vehicles.[1] In fact, the average level of performance (Mean, 52.4% correct) was about that which would have occurred had operators guessed in making their forced-choice responses. An analysis of operator responses revealed in general that regardless of vehicle type, audio signals produced by vehicles traveling at the slowest speed were most frequently identified as tracked vehicles. Regardless of vehicle type, signals produced by vehicles traveling at the fastest speed were most frequently identified as wheeled vehicles.

It appeared that operators were basing their identifications solely on signal characteristics which are due to the speed of the vehicle. This association obtained in spite of the fact that for all types of vehicles, the dominant pitch of the signal increases with speed.

There are, however, other characteristics of the signal which are determined by the type of vehicle, and which remain unique and unchanged regardless of vehicle speed. The objective of the present study was to determine whether or not naive operators can be taught to base their identifications of vehicle type on these unique characteristics of the signal.

METHOD

Exercises for use in training operators to discriminate between the two types of vehicles were constructed from signals which had been previously

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[1] A. J. Kraemer, D. L. Easley, and A. L. Miller, Measurement of Proficiency in Interpreting Ground Surveillance Radar Signals, Working Paper (Fort Knox: US Army Armor HRU, May 1962) (For Official Use Only).

recorded. After being trained on the exercises, subjects were given a criterion test to determine the level of their performance in making the discrimination.

Materials

The Exercises. Twenty-one exercise tapes were constructed, each tape consisting of a series of recorded audio signals produced by vehicle targets. One tape, consisting of 24 signals, was constructed to familiarize the subjects with the variety of vehicle signals to which they were to listen.

There were ten exercise tapes on which audio signals were presented in pairs, each tape consisting of ten pairs of signals. One signal of each pair was produced by a tracked vehicle, the other by a wheeled vehicle.

There were also ten exercise tapes on which signals were presented singly. Single-Signal Exercise 1 consisted of the same 20 signals used in constructing Paired-Signal Exercise 1; Single-Signal Exercise 2 contained the 20 signals used in preparing Paired-Signal Exercise 2; and so on.

The signals used in the 21 exercises are shown in Appendix A. The method of recording is described in an earlier report.[2]

To facilitate the learning of the signal characteristics peculiar to each vehicle type, two schemes were employed in constructing these exercises. By presenting a tracked and a wheeled vehicle as a pair of signals, the comparison of the characteristics of the two signals was facilitated. Since not only the type of vehicle, but also both vehicle speed and number of vehicles, determine the characteristics of the auditory signal, the exercises were ordered to bring in these other characteristics gradually. Reference to Table 1 will show how, at first, the exercises presented only differences which were due to vehicle type. Later the characteristics attributable to vehicle speed and number of vehicles were added.

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[2] Ibid., pages 3-4.

Table 1

Ordering of Paired-Signal Exercises in Terms of Variations in Number and Speed of Vehicles

Paired-Signal Exercise	Throughout All Items in an Exercise		Within Each Item in an Exercise	
	Number	Speed	Number	Speed
1	Same (1)	Same (10)	Same	Same
2	Same (2)	Same (15)	Same	Same
3	Same (1)	Different (5-20)	Same	Same
4	Same (1)	Different (5-20)	Same	Different
5	Different (1-2)	Same (10)	Same	Same
6	Different (1-2)	Same (15)	Different	Same
7	Different (1-2)	Different (5-20)	Same	Same
8	Different (1-2)	Different (5-20)	Same	Different
9	Different (1-2)	Different (5-20)	Different	Same
10	Different (1-2)	Different (5-20)	Different	Different

The tapes were recorded on an Ampex Model 601-2 Tape Recorder; 1½-mil mylar, low print-through tape was employed, because of its high resistance to stretching under conditions of excessive heat and dampness.

A voice announcement of the number was made at the beginning of each item. After the target signal or pair of signals, there was a short interval of silence for answering; then the signal or signals were identified by a voice announcement on the tape. In the orientation exercise the identity of the signal was announced before the signal, and the subject was not required to make an identification.

The Tests. Two forms of a test of 32 signals were constructed. Both forms contained the same signals. Since several recordings of each signal had been made, it was possible to use similar but not identical signals of the same target in the two forms of the test. It was therefore possible to construct two nearly equivalent forms of the test. Insofar as possible, signals used in the exercises were not identical to those used on the tests. The format and the method of recording were the same for the tests as for the exercises, except that no feed-back was recorded on the test tapes.

Apparatus

Both training and testing were conducted in a quiet room. The tapes were played on an Ampex Model 601-2 Tape Recorder. The signal from the recorder was fed through a Knight Amplifier (Model KN-400) to the headsets. Knight High Fidelity Headsets (Model KN-840) and AN/TPS-33 headsets were used. Volume control boxes were provided for each headset.

Subjects

Ten junior-grade Army officers served as subjects. They had no known auditory defects and no previous experience in listening to radar signals. Radar operators are enlisted men rather than officers. Officers were used as

subjects, however, because it has been frequently observed that they are in general more highly motivated in performing experimental tasks.

Procedure

Subjects were trained and tested in groups of two. After a briefing on the nature and purpose of the task, the orientation exercise was played. The experimenter then discussed the subjects' impressions of the signals and answered their questions.

The schedule of training and testing is shown in Table 2. Two sequences for presenting the exercises were employed. In Sequence A, the single-signal exercises were presented before the corresponding paired-signal comparison exercises. In Sequence B, at corresponding times the paired-signal exercises were presented first. For both sequences, reviews were given at the beginning of the afternoon sessions and at the beginning of the second day. Testing occurred at the end of both days. Half of the subjects were assigned to each training sequence. Rest periods of from 5 to 15 min. were given between exercises.

RESULTS AND DISCUSSION

The mean test scores for the entire group for both days are shown in Table 3. It was found that the performance on the first day's test was significantly better than that which would have occurred by chance; a t value of 3.01, $P<.02$, was obtained. The result of a t test between the test scores made on the first and second days was significant. ($t = 3.01$, $P<.02$). Thus the data show that it is possible to teach naive operators the characteristics by which signals of tracked and wheeled vehicles may be discriminated.

In conducting the study, a pilot test was made to determine the effect on performance of the type of headset employed. The data in Table 3 show that

Table 2

Sequences in Which the Exercise Tapes and the Criterion Tests Were Administered[a]

Exercises in Sequence A		Exercises in Sequence B	
First Day	Second Day	First Day	Second Day
	Morning Schedule of Exercise Tapes		
Orientation Tape	Paired-Signal 1	Orientation Tape	Paired-Signal 1
	Paired-Signal 2		Paired-Signal 2
Single-Signal 1	Paired-Signal 3	Paired-Signal 1	Paired-Signal 3
Paired-Signal 1	Paired-Signal 4	Single-Signal 1	Paired-Signal 4
Single-Signal 2	Paired-Signal 5	Paired-Signal 2	Paired-Signal 5
Paired-Signal 2	Single-Signal 6	Single-Signal 2	Paired-Signal 6
Single-Signal 3	Paired-Signal 6	Paired-Signal 3	Single-Signal 6
Paired-Signal 3	Single-Signal 7	Single-Signal 3	Paired-Signal 7
	Paired-Signal 7		Single-Signal 7
	Afternoon Schedule of Exercise Tapes		
Single-Signal 3	Paired-Signal 7	Single-Signal 3	Paired-Signal 7
Single-Signal 1	Single-Signal 8	Single-Signal 1	Paired-Signal 8
Single-Signal 4	Paired-Signal 8	Paired-Signal 4	Single-Signal 8
Paired-Signal 4	Single-Signal 9	Single-Signal 4	Paired-Signal 9
Single-Signal 5	Paired-Signal 9	Paired-Signal 5	Single-Signal 9
Paired-Signal 5	Single-Signal 10	Single-Signal 5	Paired-Signal 10
	Paired-Signal 10		Single-Signal 10
Criterion Test[b]	Criterion Test	Criterion Test	Criterion Test

[a]Rest periods of 5 to 15 min. were given between successive exercises.

[b]Forms A and B of the criterion test were counterbalanced between subjects on both days.

Table 3

Mean Operator Scores, in Percentages, on the Criterion Tests

Group of Subjects	First Day	Second Day
Entire Group (N = 10)	60.96	69.96
Sequence A (N = 5)	65.64	75.64
Sequence B (N = 5)	56.28	63.74
Hi-Fi Headsets (N = 6)	57.02	70.30
AN/TPS-33 Headsets (N = 4)	63.58	69.28

differences in performance due to the type of headset used during training and testing are negligible. Although the test scores made by the Sequence A Group were consistently higher than those made by the Sequence B Group (Table 3), the difference was not statistically significant.

The mean scores made on the training exercises are listed in Appendix B. As might be expected, subjects who did well on the exercises also did well on the tests. Wide differences in performance between subjects were noted during training and testing. These differences were consistent in that subjects whose performances were poor were consistently poor, and those whose performances were good were consistently good. (The correlation between the test scores for the first and second days was .71.) These findings suggest that perhaps the major problem in obtaining an adequate performance level for operators is one of selection, rather than training.

SUMMARY

The purpose of the study was to determine whether or not it is possible to teach the discrimination between the signals produced by tracked and wheeled vehicles on the AN/TPS-33 radar.

Ten junior grade officers received two days' training on twenty tape-recorded exercises. They were given criterion tests at the end of each day of training.

The results showed that it is possible to obtain an average performance which is significantly better than chance. However, the wide, consistent differences observed between individual performances suggest that obtaining a high level of performance may be largely a problem of selection rather than one of training. An effective combination of selection and training procedures should produce AN/TPS-33 operators who can discriminate signals of tracked vehicles from those of wheeled vehicles.

APPENDIX A: Signals Used in the Exercise Tapes and the Criterion Tests

ORIENTATION TAPE

Item	Single Signal
1	1 Jeep, 20 mph
2	1 Jeep, 5 mph
3	1 Jeep, 10 mph
4	1 Jeep, 15 mph
5	1 Jeep, 20 mph
6	1 Tank, 20 mph
7	1 Tank, 5 mph
8	1 Tank, 10 mph
9	1 Tank, 15 mph
10	1 Tank, 20 mph
11	1 Truck, 20 mph
12	1 Truck, 5 mph
13	1 Truck, 10 mph
14	1 Truck, 15 mph
15	1 Truck, 20 mph
16	1 APC, 20 mph
17	1 APC, 5 mph
18	1 APC, 10 mph
19	1 APC, 15 mph
20	1 APC, 20 mph

	Paired Signals	
21	Wheeled, 20 mph	Tracked, 20 mph
22	Wheeled, 15 mph	Tracked, 15 mph
23	Wheeled, 10 mph	Tracked, 10 mph
24	Wheeled, 5 mph	Tracked, 5 mph

PAIRED-SIGNAL EXERCISES[1]

Paired-Signal Exercise 1:

Item	Paired Signals	
1	1 Tank, 10 mph	1 Jeep, 10 mph
2	1 Tank, 10 mph	1 Jeep, 10 mph
3	1 Jeep, 10 mph	1 APC, 10 mph
4	1 Jeep, 10 mph	1 APC, 10 mph
5	1 Truck, 10 mph	1 APC, 10 mph
6	1 Truck, 10 mph	1 Tank, 10 mph
7	1 Truck, 10 mph	1 APC, 10 mph
8	1 Tank, 10 mph	1 Jeep, 10 mph
9	1 APC, 10 mph	1 Truck, 10 mph
10	1 Tank, 10 mph	1 Truck, 10 mph

Paired-Signal Exercise 2:

Item	Paired Signals	
1	2 Trucks, 15 mph	2 Tanks, 15 mph
2	2 APCs, 15 mph	2 Trucks, 15 mph
3	2 Jeeps, 15 mph	2 Tanks, 15 mph
4	2 Jeeps, 15 mph	2 APCs, 15 mph
5	2 Tanks, 15 mph	2 Trucks, 15 mph
6	2 Tanks, 15 mph	2 Trucks, 15 mph
7	2 Trucks, 15 mph	2 APCs, 15 mph
8	2 Jeeps, 15 mph	2 APCs, 15 mph
9	2 Jeeps, 15 mph	2 Tanks, 15 mph
10	2 Jeeps, 15 mph	2 APCs, 15 mph

Paired-Signal Exercise 3:

Item	Paired Signals	
1	1 APC, 20 mph	1 Jeep, 20 mph
2	1 Truck, 5 mph	1 Tank, 5 mph
3	1 Truck, 10 mph	1 APC, 10 mph
4	1 Tank, 15 mph	1 Jeep, 15 mph
5	1 Truck, 20 mph	1 Tank, 20 mph
6	1 APC, 15 mph	1 Jeep, 15 mph
7	1 APC, 5 mph	1 Truck, 5 mph
8	1 Tank, 10 mph	1 Jeep, 10 mph
9	1 Truck, 20 mph	1 Tank, 20 mph
10	1 APC, 5 mph	1 Jeep, 5 mph

[1]The 20 signals used in Paired-Signal Exercise 1 were presented separately in Single-Signal Exercise 1; those used in Paired-Signal Exercise 2 were presented separately in Single-Signal Exercise 2; and so on.

Paired-Signal Exercise 4:

Item	Paired Signals	
1	1 APC, 20 mph	1 Jeep, 5 mph
2	1 Jeep, 20 mph	1 APC, 5 mph
3	1 Jeep, 5 mph	1 Tank, 20 mph
4	1 Truck, 10 mph	1 APC, 20 mph
5	1 Truck, 15 mph	1 Tank, 5 mph
6	1 Truck, 5 mph	1 Tank, 15 mph
7	1 Truck, 10 mph	1 APC, 15 mph
8	1 Tank, 20 mph	1 Jeep, 15 mph
9	1 Jeep, 20 mph	1 Tank, 15 mph
10	1 APC, 10 mph	1 Truck, 5 mph

Paired-Signal Exercise 5:

Item	Paired Signals	
1	1 Truck, 10 mph	1 Tank, 10 mph
2	2 Tanks, 10 mph	2 Jeeps, 10 mph
3	1 APC, 10 mph	1 Truck, 10 mph
4	2 Jeeps, 10 mph	2 APCs, 10 mph
5	1 Tank, 10 mph	1 Jeep, 10 mph
6	2 APCs, 10 mph	2 Trucks, 10 mph
7	1 Jeep, 10 mph	1 APC, 10 mph
8	2 APCs, 10 mph	2 Trucks, 10 mph
9	2 Tanks, 10 mph	2 Trucks, 10 mph
10	1 Jeep, 10 mph	1 Tank, 10 mph

Paired-Signal Exercise 6:

Item	Paired Signals	
1	1 Truck, 15 mph	2 APCs, 15 mph
2	1 Jeep, 15 mph	2 APCs, 15 mph
3	1 Truck, 15 mph	2 Tanks, 15 mph
4	2 Trucks, 15 mph	1 APC, 15 mph
5	1 Jeep, 15 mph	2 Tanks, 15 mph
6	2 APCs, 15 mph	1 Jeep, 15 mph
7	2 Tanks, 15 mph	1 Truck, 15 mph
8	1 Jeep, 15 mph	2 Tanks, 15 mph
9	1 Tank, 15 mph	2 Jeeps, 15 mph
10	1 Truck, 15 mph	2 APCs, 15 mph

Paired-Signal Exercise 7:

Item	Paired Signals	
1	1 Tank, 20 mph	1 Truck, 20 mph
2	1 Jeep, 5 mph	1 APC, 5 mph
3	2 Tanks, 15 mph	2 Jeeps, 15 mph
4	2 Trucks, 15 mph	2 Tanks, 15 mph
5	1 Truck, 5 mph	1 APC, 5 mph
6	2 Jeeps, 20 mph	2 APCs, 20 mph
7	1 APC, 20 mph	1 Jeep, 20 mph
8	2 Tanks, 5 mph	2 Jeeps, 5 mph
9	1 Tank, 10 mph	1 Truck, 10 mph
10	2 APCs, 20 mph	2 Trucks, 20 mph

Paired-Signal Exercise 8:

Item	Paired Signals	
1	1 Truck, 20 mph	1 Tank, 15 mph
2	2 Jeeps, 10 mph	2 Tanks, 5 mph
3	2 APCs, 5 mph	2 Jeeps, 15 mph
4	2 Trucks, 5 mph	2 APCs, 20 mph
5	1 Truck, 5 mph	1 APC, 20 mph
6	1 Tank, 10 mph	1 Jeep, 5 mph
7	2 Jeeps, 5 mph	2 Tanks, 10 mph
8	1 APC, 15 mph	1 Truck, 20 mph
9	1 APC, 15 mph	1 Jeep, 20 mph
10	2 Tanks, 5 mph	2 Trucks, 20 mph

Paired-Signal Exercise 9:

Item	Paired Signals	
1	1 APC, 10 mph	2 Trucks, 10 mph
2	2 APCs, 20 mph	1 Jeep, 20 mph
3	2 APCs, 5 mph	1 Truck, 5 mph
4	1 Jeep, 20 mph	2 Tanks, 20 mph
5	2 Jeeps, 20 mph	1 Tank, 20 mph
6	1 Truck, 10 mph	2 Tanks, 10 mph
7	2 Jeeps, 15 mph	1 APC, 15 mph
8	2 Trucks, 20 mph	1 APC, 20 mph
9	2 Jeeps, 10 mph	1 Tank, 10 mph
10	2 Trucks, 5 mph	1 Tank, 5 mph

Paired-Signal Exercise 10:

Item	Paired Signals	
1	2 Jeeps, 5 mph	1 APC, 10 mph
2	1 Jeep, 10 mph	2 APCs, 5 mph
3	1 Tank, 20 mph	2 Trucks, 15 mph
4	2 Tanks, 15 mph	1 Truck, 20 mph
5	2 Jeeps, 20 mph	1 Tank, 5 mph
6	2 Trucks, 5 mph	1 APC, 20 mph
7	2 Tanks, 15 mph	1 Truck, 5 mph
8	1 APC, 10 mph	2 Jeeps, 20 mph
9	2 Jeeps, 10 mph	1 APC, 20 mph
10	1 Tank, 5 mph	2 Trucks, 15 mph

CRITERION TESTS

Form A

Item	Signal
1	1 Truck, 20 mph
2	2 Trucks, 5 mph
3	1 Tank, 5 mph
4	1 Jeep, 10 mph
5	2 Tanks, 15 mph
6	2 Tanks, 20 mph
7	1 Jeep, 20 mph
8	2 Jeeps, 5 mph
9	1 Truck, 10 mph
10	1 Tank, 15 mph
11	2 APCs, 20 mph
12	2 Jeeps, 15 mph
13	1 APC, 20 mph
14	1 Tank, 20 mph
15	1 APC, 5 mph
16	2 Trucks, 20 mph
17	2 Jeeps, 20 mph
18	2 Tanks, 10 mph
19	1 APC, 10 mph
20	2 Trucks, 15 mph
21	2 APCs, 10 mph
22	1 Jeep, 15 mph
23	1 Jeep, 5 mph
24	1 Tank, 10 mph
25	1 APC, 15 mph
26	2 Tanks, 5 mph
27	2 Jeeps, 10 mph
28	1 Truck, 15 mph
29	2 APCs, 15 mph
30	2 APCs, 5 mph
31	2 Trucks, 10 mph
32	1 Truck, 5 mph

Form B

Item	Signal
1	1 Jeep, 15 mph
2	2 Trucks, 5 mph
3	2 APCs, 10 mph
4	2 Trucks, 15 mph
5	1 Tank, 10 mph
6	1 Truck, 5 mph
7	2 Tanks, 15 mph
8	1 Jeep, 5 mph
9	1 Truck, 20 mph
10	1 Truck, 15 mph
11	1 Tank, 5 mph
12	1 APC, 5 mph
13	1 APC, 10 mph
14	2 Jeeps, 15 mph
15	2 Tanks, 10 mph
16	2 APCs, 5 mph
17	2 Trucks, 10 mph
18	1 Jeep, 10 mph
19	2 Jeeps, 20 mph
20	2 Trucks, 20 mph
21	2 Jeeps, 5 mph
22	1 APC, 20 mph
23	1 Truck, 10 mph
24	2 APCs, 20 mph
25	2 Jeeps, 10 mph
26	1 APC, 15 mph
27	1 Jeep, 20 mph
28	1 Tank, 20 mph
29	2 Tanks, 20 mph
30	2 APCs, 15 mph
31	1 Tank, 15 mph
32	2 Tanks, 5 mph

APPENDIX B: Mean Operator Scores, in Percentages, on the Training Exercises

Mean Operator Scores in Percentages, on the Training Exercises (N = 10)

Exercise Tape	Mean Score	S. D.	Range of Scores
	Paired-Signal Exercises		
1	82.0	12.29	60 - 100
2	74.0	12.65	50 - 90
3	69.0	8.76	60 - 80
4	65.0	22.73	30 - 90
5	73.0	16.36	50 - 100
6	89.0	11.97	70 - 100
7	77.0	14.18	50 - 90
8	84.0	16.46	50 - 100
9	79.0	15.24	60 - 100
10	79.0	15.24	50 - 100
	Single-Signal Exercises		
1	69.0	15.78	45 - 85
2	69.5	12.12	40 - 80
3	68.0	5.87	60 - 80
4	75.0	13.33	65 - 95
5	63.5	14.54	40 - 85
6	77.5	17.36	45 - 95
7	72.0	8.56	60 - 85
8	77.0	12.29	60 - 95
9	78.0	13.37	50 - 95
10	75.5	16.41	45 - 100

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The purpose of this study was to determine whether or not it is possible to teach the discrimination between the signals produced by tracked and wheeled vehicles on the AN/TPS-33 radar. Ten junior grade officers received two days' training on twenty tape-recorded exercises. They were given criterion tests at the end of each day of training. The results showed that it is possible to obtain an average performance which is significantly better than chance.

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